

Acanthophora, a Possible Invader of the Marine Flora of Hawaii¹

MAXWELL S. DOTY²

IN THE FALL OF 1952, a small algal fragment was brought to the author from Pearl Harbor³ by Mr. Charles Cutress. In April, 1953, a much larger piece of the alga was brought in by Mr. Spencer Tinker, who had found it washed ashore near the Waikiki Beach Laboratory of the University of Hawaii. Both collections were readily determined as representing a species of *Acanthophora* Lamouroux (1813: 132), a rhodophytan genus. This genus is distinct and clearly recognizable among the floral elements occurring in this part of the world. A search of the literature and the herbaria available revealed no Pacific records of this genus from the Hawaiian Islands or, with one exception, east of the Western Caroline and Marianas islands north of the equator.

Other collections during succeeding years, and field observations as well, revealed a huge increase in the abundance of the species in Hawaii during the next few years. In May, 1953, Dr. D. W. Strasburg found this alga "in abundance" at Keehi Lagoon, between Pearl Harbor and the Port of Honolulu on the leeward side of Oahu. Later the same month, a dense growth of the alga was found by the author (numbered 10774) and Dr. E. Y. Dawson at Hauula, north of Honolulu, on the windward side of the island of Oahu. Parts of this collection are the earliest collections from Hawaii represented in both the Bishop Museum and the University of California herbaria. From that time on, *Acanthophora* has been so common on the leeward

side of Oahu that it has not often been preserved as an herbarium specimen.

Finally, during June, 1956, Dr. Otto Degener collected and sent in a specimen (his no. 24105) from Mokuleia on the windward shore of the island of Oahu, northwestward from Honolulu, collected by himself, Miss Marie Neal, and Dr. Constance Hartt, with the annotation "... ubiquitous some distance within the reef; observed very rare here last year. This is first time aggressive marine alga threatening native kinds." Certainly it appears to be replacing (crowding out) elements of the native flora. Degener, who has paid close attention to the reef population at this particular site, feels the alga probably was not there until, at most, 2 years before this collection was made.

Not only have frequency of observance and density of standing crop increased, but the distribution has been that of a progressive encircling of Oahu, one of the few islands of the Hawaiian Group where *Acanthophora* has been found.

The alga has spread to Kauai, another of the Hawaiian Islands. Mr. Jan Newhouse has passed on local stories that the alga was not found around Kauai until about 1954 or 1955, and the observation that it is now ubiquitous. This genus was recorded from Kauai by Kohn and Helfrich (1957: 243). Their mention of the genus was based on observations of Newhouse about November, 1956, and was not included among the algae they collected and had identified by Dawson at the time their earlier work (Helfrich and Kohn, 1955) was completed in October and November of 1955. It has been found neither among our earlier extensive collections from Kauai nor by Newhouse among his, but during August 1960, Dr. Charles Lamouroux and Mr. Tadayuki Kato made a collection (Lamouroux coll. no. 1542) of *Acanthophora* on Kauai at Poipu Beach.

Specific, though in part cursory, searches during 1960 for *Acanthophora* on the islands of

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² Botany Department, University of Hawaii, Honolulu 14, Hawaii.

³ According to Mr. Mikihiko Oguri, this algal collection probably came from West Loch, between Lualaunui Island and the northwestern shore.

Hawaii, Lanai, and Maui variously by Robert K. S. Lee, Mikihiro Oguri, Warren Wilson, and the author have resulted in no traces of this alga being found with one exception. The exception is a collection made by the author (numbered 19431), Mrs. Meng Sung Doty and Mr. Lee along the north shore of Lanai in November, 1960, where the alga was washed onto the muddy sand beach in abundance, free or attached to shells, coral, or even rocks up to 2 lb. in weight. Unfortunately, the Kawaihae area on Hawaii and the shores of Molokai have not been specifically searched for this genus, but our collections made during earlier years from these places do not include *Acanthophora*.

In the light of the ability and persistent vigor of the algologists who have at one time or another concerned themselves with the marine algae of the Hawaiian Islands, e.g., Drs. W. A. Setchell, Josephine Tilden, G. F. Papenfuss,⁴ I. A. Abbott, and earlier, the Misses Minnie Reed and Marie Neal, and Mrs. Nina H. Loomis, it seems unlikely that this alga would have been overlooked had it been consistently present. It is a conspicuous alga. The older Polynesians in Hawaii seem to have had no name for *Acanthophora*. If pressed for a Polynesian name nowadays, the common man professing native acumen will apply local names such as *manauea*, the name widely used formerly for species of other genera, such as *Gracilaria* (now usually referred to by the Japanese name, *ogo*).

Identifying the Hawaiian alga has led to a consideration of the differences purported to exist between the several species reported in the Pacific. Many variants can be found in the material that has been available for this study from both the Atlantic and the Pacific, but for the present it is felt that the many forms found might best be treated as variants of one species. *Acanthophora spicifera*⁵ (Vahl) Boergesen (1910) is the name for this species having priority insofar as we know.

Among the most common names⁶ considered here as having been applied to the taxon *A. spicifera*, as found in the Pacific, is *A. orientalis* J. Agardh (1863). In describing *A. orientalis* as a new species, J. Agardh listed the Marianas Islands, of which Guam (13° N., 145° E.)⁷ is one, as the source of one of the two collections he had seen. The other collection was probably from Manila Bay (14° N., 121° E.) in the Philippines. Safford (1905: 30–32) says that in the Marianas, the islands Guam, Rota (14° N., 145° E.) and Tinian (15° N., 146° E.) were visited by the Freycinet expedition. The material of this expedition from these islands is believed to be the source of one of the two collections Agardh reported. In his text, Safford (1905: 177 f.) lists *A. orientalis* from Guam and we presume this to be based on the Freycinet record, since Safford also says Dumont d'Urville collected several new species of algae on Guam. We ourselves have seen no specimens from Guam, despite a search through the several collections, now in our possession, which were made there by Mr. Ernani Meñez in 1960.

Except for the reports from Hawaii, the genus is not known to occur in the Pacific east of the Marianas other than in the Ponape region, where it has been reported by Yamada (1944: 44) as *A. muscoides* (L.) Bory from Ant (7° N., 158° E.), an atoll 8 mi. to the southwest of Ponape.

It is common about the large subcontinental or continent-related islands of the far western Pacific and, as *A. spicifera*, according to Womersley (1958), in northern Australia. The genus is reported (Kanda, 1944: 749) from Palau (7° N., 134° E.) as *A. orientalis*. As *A. thierii* Lamx. the genus is recorded from the Admiralty Islands (probably 2° S., 147° E.) and Tongatabu (21° S., 175° W.) by Dickie (1875b: 238, 235, resp.) and from Torres Straits (10° S., 143° E.) by Dickie (1876: 447). *Acanthophora* is common in the warmer part of the Atlantic, and Lamouroux (1813) believed the genus to be circumequatorial.

It seems entirely possible that this species

⁴ In correspondence, Dr. Papenfuss tells us that neither he nor Setchell found this genus in Hawaii, and that the only Hawaiian specimens in the University of California herbarium are duplicates of the Hauula collections sent in by Dawson and mentioned above.

⁵ Basonym=*Fucus spiciferus* Vahl, 1802.

⁶ The only similar species not mentioned otherwise here appears to be *A. aoki* Okamura, 1934.

⁷ The approximate latitude and longitude in degrees is given for the convenience of those interested in the location of the places named.

could have arrived in Hawaii from the west on a ship bottom, i.e., a man-made facilitation of the oceanic drift method of dispersal. This would be the carrying of an organism "upstream."⁸ The progressive increase in abundance around the island over several years' time, and, recently, what appears to be a leveling off in abundance, is considered evidence of an introduction into the Honolulu–Pearl Harbor area. The Honolulu–Pearl Harbor shore area is the part of the state having the greatest traffic with regions of the world where *Acanthophora* has been known as a common component of the flora for a long time. This area is not climatically extreme for the state. However, since Honolulu has been in contact with the East and West via ship for centuries, it seems likely that some recent unusual occurrence may have implemented this transport. The three following events have come to our attention and are considered in this regard.

First, the recent warming of North Pacific waters (e.g., since the low temperature year of 1955 at Christmas Island, 2° N., 157° W.) would not, it seems, be accountable for the following reasons: first, the warm temperatures did not begin until after the alga was well known in Hawaii, and, secondly, there has been little abnormality of water temperatures in the Hawaiian area itself.

A second unusual event that may have led to the introduction is the increase in traffic between the Honolulu–Pearl Harbor area and the Far East during World War II, 1941–45, and during the Korean Police Action, 1950–53. The idea is that a number of small introductions at nearly the same time might have provided together a sufficiently large inoculation for the species to become established. From the rate of spread we tend to exclude the first period. The second is more timely. There is no special evidence that would lead one to choose this latter as the probable period, though such changes in oceanic traffic have been held to account for

the distribution of barnacles in some cases elsewhere in the world.

A heavily fouled barge, the "Yon 146," towed to Pearl Harbor from Guam, provides an example of the third, and more specific, type of event that may have led to the establishment of *Acanthophora* in Hawaii. The idea here is that one heavily "fouled bottom" could have provided a sufficiently large inoculation for the species to become established. Upon arriving in Pearl Harbor February 3, 1950, this "fuel oil barge (non-self-propelled)" was placed in a dry dock. The Pearl Harbor dry docks are about 12 km. by water and 8 km. in a straight line from the place Cutress collected the first material of *Acanthophora* found in Hawaii. The dry dock is about 30 km. by water from the place Tinker first found this species of *Acanthophora*.

Fish and gastropod collections were made both from the growths, often 3–8 in. thick, on the barge and from the small pools left under the barge in the otherwise dry dry dock. They were made, at least in part, on April 10, 1950, and variously by Tinker, George Campbell, and Kenneth A. Wong. This vessel, 200 ft. long, 56 ft. in beam, concrete-hulled, under different descriptive names, has been mentioned as a possible means of fish introduction by several authors, e.g., by Gosline and Brock (1960: 26), who have studied collections made on it. The same vessel is reported by Edmondson (1951: 183, 212) as having brought in invertebrates which have become established,⁹ such as the brachyuran crab, *Schizophrys aspere*, common to the far western Pacific. Chapman and Schultz

⁸ This is the customarily postulated direction of migration in deriving the populations of Hawaii, as summarized by Zimmerman (1948), and Gosline and Brock (1960). Ladd (1960) has emphasized a somewhat different possible mode of origin for the populations of the Pacific islands.

⁹ From accounts of long-time residents of the area, known distribution of the species, and information in the literature, it seems to me almost certain that *Cotylorhizoides pacificus* (Mayer) and *Cassiopea medusa* (Light), both Rhizostomae, were accidentally introduced to the Pearl Harbor area during the 1941–45 period. The type locality of these two medusae is the Philippine Islands. In Hawaii both were restricted to Pearl Harbor until about 1950. About this time, *Cassiopea* appeared in Honolulu Harbor and the Ala Wai Canal. Later, 1953–54, *Cotylorhizoides* appeared in Kaneohe Bay. Until the time of my departure (December, 1955) neither medusa was known from the other Hawaiian Islands, Line Islands, Marshalls, Gilberts, etc. Both forms undoubtedly came to Hawaii as scyphistoma on ships or the like, as neither are medusae of the open ocean.—C. E. Cutress, June, 1960.

(1952) concluded there was no evidence among the fish records they obtained that species had been brought to Hawaii in the fouling population on that barge. Dr. C. M. Burgess, who, along with Campbell and Tinker, provided much of the specific information on these events, told the author that the species of the molluscan genus *Cypraea* brought in on this vessel, the "Yon 146," did not become established in Hawaii, and this has been affirmed by Dr. Alison E. Kay, who is a student of this genus.

In commenting upon *Tripterygion hemimelas* Kner & Steindachner and *Ecsenius hawaiiensis* Chapman & Schultz, two blennioid fishes reported to have been collected from the pools of water in the dry dock holding the "Yon 146," Strasburg (1956: 245 f.) notes that the specimens of *T. hemimelas* were similar to a species from the Samoan Islands (14° S., 171° W.). The service record of this barge, as far as the author has been able to trace it, indicates that it was tied up at Apra (13° N., 145° E.), Guam, from 1945 to the date it was towed to Pearl Harbor, a period of about 4 years. Thus it does not seem likely that it would have been directly the means by which a Samoan fish would have been introduced into Hawaiian waters. Whether *T. hemimelas* occurs in Guam or not is not known to the present author.

Possibly the blennioid fish, *Omobranchus elongatus* (Peters), was brought to Hawaii (Strasburg, 1956: 257) from the Samoan area along with chunks of reef rock bearing living specimens of the giant clam, *Tridacna*. At least for the present, this splendid possible avenue of introduction is discounted; though *Acanthophora* has been reported (Reinbold, 1896) as *A. orientalis* from Upolu (14° S., 171° W.), Western Samoa.

Individual ships have been cited previously as the means by which algae have been introduced into the Central Pacific. Dickie (1875a: 33) published a note to the effect that *Ulva latissima* Linnaeus was introduced to Mangaia (22° S., 158° W.) in the Cook Islands when a whaling ship from the Antarctic was wrecked there on the reef in 1852. There is the possibility, however, that the wrecked ship merely provided a favorable habitat, in which habitat an ulvoid alga interpreted by Dickie as repre-

sentative of this specific taxon appeared. In form the ulvoid algae, of the larger benthic algae, are among the most plastic in respect to environmental conditions.

Kohn (1959: 81) records *Acanthophora* (using the binomial *A. orientalis*) from Kaneohe Bay, Oahu, Hawaii, where it was the substratum upon which the eggs of *Conus quercinus* were found attached in February, 1956. *C. quercinus* has been recorded for Hawaii for many years (e.g., Bryan, 1915: 454), but the alga for only a few years. If *C. quercinus* is very host-specific in its egg-case depositing, this observation of Kohn's could be taken to imply long presence of *Acanthophora* in Hawaii. Though the alga is independent of the mollusc, if the mollusc is restricted to the algal species for egg-case deposition, the alga would probably have had to be here first and it would have taken many years for the mollusc to develop modified egg-case depositing habits including *Acanthophora* as a host. Our impression¹⁰ is, however, that egg-case attachment by molluscs is not very specific, substratum-wise, and therefore, that there is no implication in Kohn's record that *Acanthophora* grew in the islands, say, in 1915.

After considering the types of events described above, we feel that it is most likely that *A. spicifera* arrived recently in Hawaii via the fouled bottom of a ship. Aside from the ordinary ship traffic, similar opportunities for introduction by vessels other than the "Yon 146" are known. One of these opportunities is provided in the case of a similar vessel, the "Yogn 41," which was towed from Subic Bay (15° N., 120° E.) in May, 1947. This "gasoline barge (non-self-propelled)" was dry-docked in February, 1950, in Pearl Harbor. While Subic Bay is unknown phycologically, *A. spicifera* is common in the general area, e.g., in Manila Bay a few miles to the south it is abundant. However, from the timing of the events and from the rate of spread after the first specimens were found, it is believed that

¹⁰ A letter received since from Prof. J. M. Ostergaard supports this impression concerning the specificity of egg-case deposition by *Conus* and tells us of his "finds" of *C. quercinus* in the Honolulu Harbor area as dead shells in 1902 and 1905 and as living shells in 1915.

an earlier vessel would be much less likely a source of the introduction of *A. spicifera* than the "Yon 146."¹¹

REFERENCES

- AGARDH, J. G. 1863. Species genera et ordines algarum...2. Part 8: 701-1278.
- BOERGESEN, F. 1910. Some new or little known West Indian Florideae, II. Botanisk Tidskrift 30. 177-207.
- BRYAN, W. A. 1915. Natural History of Hawaii. . . . Privately printed, The Hawaiian Gazette Co., Ltd., Honolulu. 596 pp.
- CHAPMAN, WILBERG M., and LEONARD P. SCHULTZ. 1952. Review of the fishes of the blennioid genus *Ecsenius*, with descriptions of five new species. Proc. U. S. National Mus. 102 (3310): 507-528.
- DICKIE, G. 1875a. Notes on algae from the Island of Mangaia, South Pacific. Jour. Linn. Soc. 15: 30-33.
- 1875b. Contributions to the botany of the expedition of H.M.S. "Challenger" Algae, chiefly Polynesian. Jour. Linn. Soc. 15: 235-246.
- 1876. Notes on algae collected by H. N. Moseley, M. A., of H.M.S. "Challenger," chiefly obtained in Torres Straits, Coasts of Japan, and Juan Fernandes. Jour. Linn. Soc. 15: 446-455.
- EDMONDSON, CHARLES HOWARD. 1951. Some Central Pacific crustaceans. Occ. Pap. Bishop Mus. 20(13): 183-243.
- GOSLINE, WILLIAM A., and VERNON E. BROCK. 1960. Handbook of Hawaiian Fishes. University of Hawaii Press, Honolulu. ix + 372 pp., illus.
- HELFRICH, PHILIP, and ALAN J. KOHN. 1955. A survey to estimate the major biological effects of a dredging operation by the Lihue Plantation Co., Ltd., on North Kapaa Reef, Kapaa, Kauai. Preliminary Report. Mimeographed, privately distributed. 31 pp. (An expansion of one aspect of this work was published by Kohn and Helfrich, see below.)
- KANDA, TIYOITI. 1944. Ecological studies on marine algae from Kororu and adjacent islands in the south sea islands. Palao Tropical Biol. Sta. Studies II(4): 733-800.
- KOHN, ALAN J. 1959. The ecology of *Conus* in Hawaii. Ecological Monog. 29(1): 47-90.
- KOHN, ALAN J., and PHILIP HELFRICH. 1957. Primary organic productivity of a Hawaiian coral reef. Limnol. Oceanogr. 2(3): 241-251.
- LADD, HARRY S. 1960. Origin of the Pacific island molluscan fauna. Amer. Jour. Sci., Bradley Volume 258A: 137-150.
- LAMOUREUX, J. V. F. 1813. Essai sur les genres de la famille des Thalassiphytes non articulées. Ann. Mus. Hist. Nat. Paris 20: 21-47, 115-139, 267-293, pl. 7-13.
- OKAMURA, K. 1934. Icones of Japanese Algae. Vol. VII. p. 5, pl. 318, figs. 15-17.
- REINBOLD (ITZEHOE), D. 1896. Meeresalgen. In: F. Reinecke, Die Flora der Samoa-Inseln. Botanische Jahrbücher 23: 266-275.

¹¹Though we do not know what other biological consternation may be associated with this vessel, it may cause little more for Hawaiian biologists, for it is reported to have been sunk in Subic Bay on October 16, 1955.

- SAFFORD, WILLIAM EDWIN. 1905. The Useful Plants of the Island of Guam; with an Introductory Account of the...Island. U. S. Dept. Agr., Contrib. U. S. Nat. Herb. 9. 416 pp.
- STRASBURG, DONALD W. 1956. Notes on the blennioid fishes of Hawaii with descriptions of two new species. *Pacif. Sci.* 10(3): 241-267.
- VAHL, MARTIN. 1802. Endeel krytogamiske Planter fra St. Croix. *Skrivter af Naturhistorie-Selskabet* 5(2). (Not seen.)
- WOMERSLEY, H. B. S. 1958. Marine algae from Arnheim Land, North Australia. Records of the American-Australian Expedition to Arnheim Land. 3(4): 139-161.
- YAMADA, YUKIO. 1944. A list of the marine algae from the atoll of Ant. *Sci. Pap. Inst. Algological Res. Hokkaido Univ.* 3: 31-45.
- ZIMMERMAN, ELWOOD C. 1948. Insects of Hawaii, Vol. 1. Introduction. University of Hawaii Press, Honolulu. xx + 206 pp.